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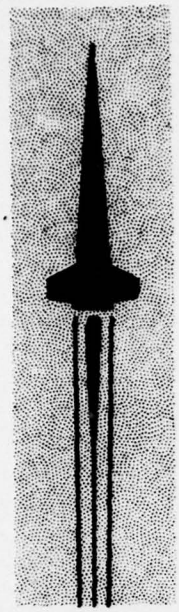

TECHNICAL REPORT T-79-5

DRAG INVESTIGATIONS OF TOWED TARGET BANNERS

U.S. ARMY MISSILE RESEARCH AND DEVELOPMENT COMMAND

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Systems Simulation Directorate
Technology Laboratory

11 December 1978

Redstone Arsenal, Alabama 35809

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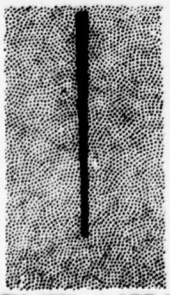

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Gunnery banners are presently used by the Army as targets for air defense gun and missile systems. The standard banner is a 2-½ × 12-ft rectangular configuration and is normally towed 500 ft from the tractor vehicle. The drag coefficient for this banner is 0.0364, which is five to seven times greater than that of an equivalent flat plate. In order to investigate lower drag banners, a series of manned flight tests were conducted in the spring of 1975. These tests were done for a series of full-scale target banners to

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20. ABSTRACT (Continued).

determine the influence on drag of flight Reynolds number, the ratio of length to width, planform shape, material properties, and towbar configuration.

CONTENTS

I. INTRODUCTION

The use of the Variable Speed Training Target (VSTT) to tow gunnery targets at high speed at low altitudes motivated the study of banner drag. The standard nylon gunnery target banner, a rectangular shape which is 2-ft wide by 12-ft long, results in a drag coefficient, $C_D = F_D/q_\infty A_{ref} = 0.0364$. This is approximately five times greater than that of an equivalent flat plate. The useful flight envelope of the VSTT can be substantially increased by developing a low drag target configuration. Flight tests were done for a series of full scale target banners to determine the influence on drag of flight Reynolds number, the ratio of banner length to width, the banner planform shape, material properties, and the towbar configuration.

II. TEST PROCEDURE

The aircraft used in this series of tests was the LTV A7-D. Each banner was towed using 500 ft of 0.064 diameter cable except the last banner which used 0.072 diameter cable. The first, second, and ninth banners used a 7 × 7 cable with a strength of 500 lb; all other banners were a 7 × 1 cable with 880-lb strength.

III. RESULTS

The flight test results are summarized in Table 1 for rectangular banner shapes. The tests demonstrated a drag coefficient for the standard banner equal to 0.0364 which is in agreement with the value of 0.0357 obtained in a wind tunnel simulation.[1] No significant dependence of drag coefficient flight Reynolds number was shown by the test data as illustrated in Figure 1 for rectangular banners. The test data for Cases 1 and 2 of Table 1 indicate that a small drag reduction can be obtained by increasing the aspect ratio, L/W, of the banner with a standard towbar arrangement, as shown in Figures 2(a) and 2(b). The contribution of the towbar drag was found experimentally to be 6% of the total drag for the standard configuration compared to a calculated value of 9%. Mechanical characteristics of the banner material had the largest influence on total banner drag. The combined effects due to variation in material porosity, cloth weight, and weave pattern for Case 4 of Table 1 resulted in a 20% reduction in drag coefficient when compared to the standard banner.

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[1] Drag Investigation of Gunnery Target Banners for the Beech VSTT, Beech Aircraft Corporation, Wichita, Kansas, January, 1978, Report No. 1089E221 MTI.

Flight tests done with triangular shaped banners were inconclusive for definition of drag coefficient due to progressive fraying and destruction of banners during flight. The data suggest that no drag advantage will be obtained with triangular banners and that material strength requirements must be increased relative to the standard banner material.

The banner drag coefficients obtained in the flight tests were compared to drag coefficients for a variety of banner and windsock configurations suitable for towing. When compared on the basis of equal projected area for target visibility requirements, no flexible target banner concept was found which resulted in a lower drag coefficient than that of Case 4 of Table 1.

The tow banner configurations are summarized in Table 2; the test data[2] are summarized in Figure 3. Some of the data are taken from the 1969 banner test.[3] The banner with the maximum porosity showed the least drag for all altitudes tested.

IV. CONCLUSIONS

The following conclusions were drawn:

a) Banner material has a substantial influence on the drag coefficient of rectangular banners. The drag coefficient is reduced by an increase in material porosity.

b) The standard towbar contributes approximately 6% of total towed configuration drag.

c) The towed banner and cable were immersed in an aerodynamically disturbed environment due to wing tip vortices and turbojet exhaust. It is probable that observed banner drag coefficient is greater than drag coefficient obtained in an undisturbed environment.

d) No valid drag coefficients were obtained for triangular banners due to progressive fraying of banners. Triangular banners, even when made of standard material, cannot sustain as high a dynamic pressure as rectangular banners.

e) Banner drag coefficient does not vary significantly with Reynolds number over the range of test values.

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[2]Patrick, Grady E. Jr., "Tow Target Data Program Phase II," US Army Missile Command, Redstone Arsenal, Alabama, June, 1969, Internal Report.

[3]Alston, John D., "Tow Target Drag Data Program," US Army Missile Command, Redstone Arsenal, Alabama, June 1969, Internal Report.

TABLE 1. FLIGHT TEST SUMMARY FOR RECTANGULAR BANNERS

Item	Description	Drag Coefficient
1	2- × 12-ft standard banner material	0.0364
2	2- × 15-ft standard banner material	0.0323
3	2- × 12-ft standard banner material, long towbar	0.0386
4	3- × 12-ft lightweight Nylon, standard weave	0.0293
5	2.33- × 12-ft lightweight polypropylene	0.0344
6	2- × 12-ft heavyweight polypropylene	0.0380

$C_D \equiv F_D/(q_{RES}\ A_{REF})$

TABLE 2. SUMMARY OF TOW BANNER CONFIGURATIONS

Banner No.	Shape	Material	Material Wt. (oz/yd^2)	Size	Planform Area (ft^2)	Comments
1	Rectangle	Nylon	4.6	2 × 12 ft	24	Standard X-100 banner.
2	Rectangle	Polypropylene	2.3	28.5 × 142 in.	28	Lightweight material with loose mesh-type weave
3	Rectangle	Polypropylene	2.3	2 × 12 ft	24	Heavyweight material with same weave as No. 2
4	Right Triangle	Nylon	4.6	4 × 12 ft	24	Triangle used to determine effect of shape on drag
5	Right Triangle	Polypropylene	2.3	4 × 12 ft	24	To determine effect of shape and material on drag
6	Rectangle	Nylon	4.6	2 × 12 ft	24	4-ft towbar to determine towbar drag - standard X-100 banner
7	Right Triangle	Polypropylene	2.3	4 × 15 ft	30	To determine combined effect of shape, length, and material
8	Right Triangle	Nylon	4.6	4 × 15 ft	30	To determine effect of shape and length on drag - standard material
9	Rectangle	Nylon	4.6	2 × 15 ft	30	To determine effect of length on drag - standard material
10	Rectangle	Nylon	3.4	35 in. × 12 ft	35	Jalbert design of plain nylon mesh

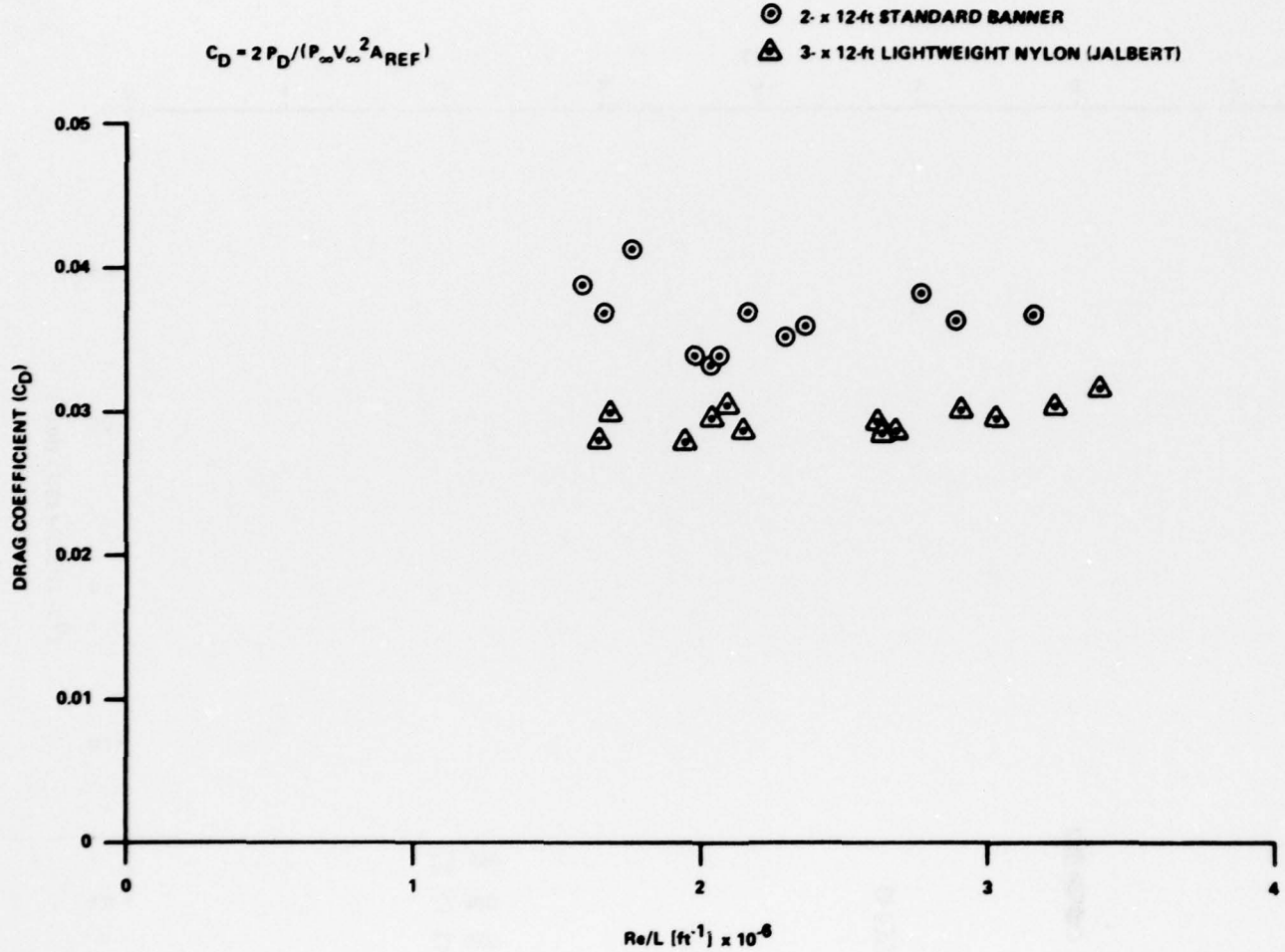


Figure 1. Reynolds number effect on banner drag coefficient.

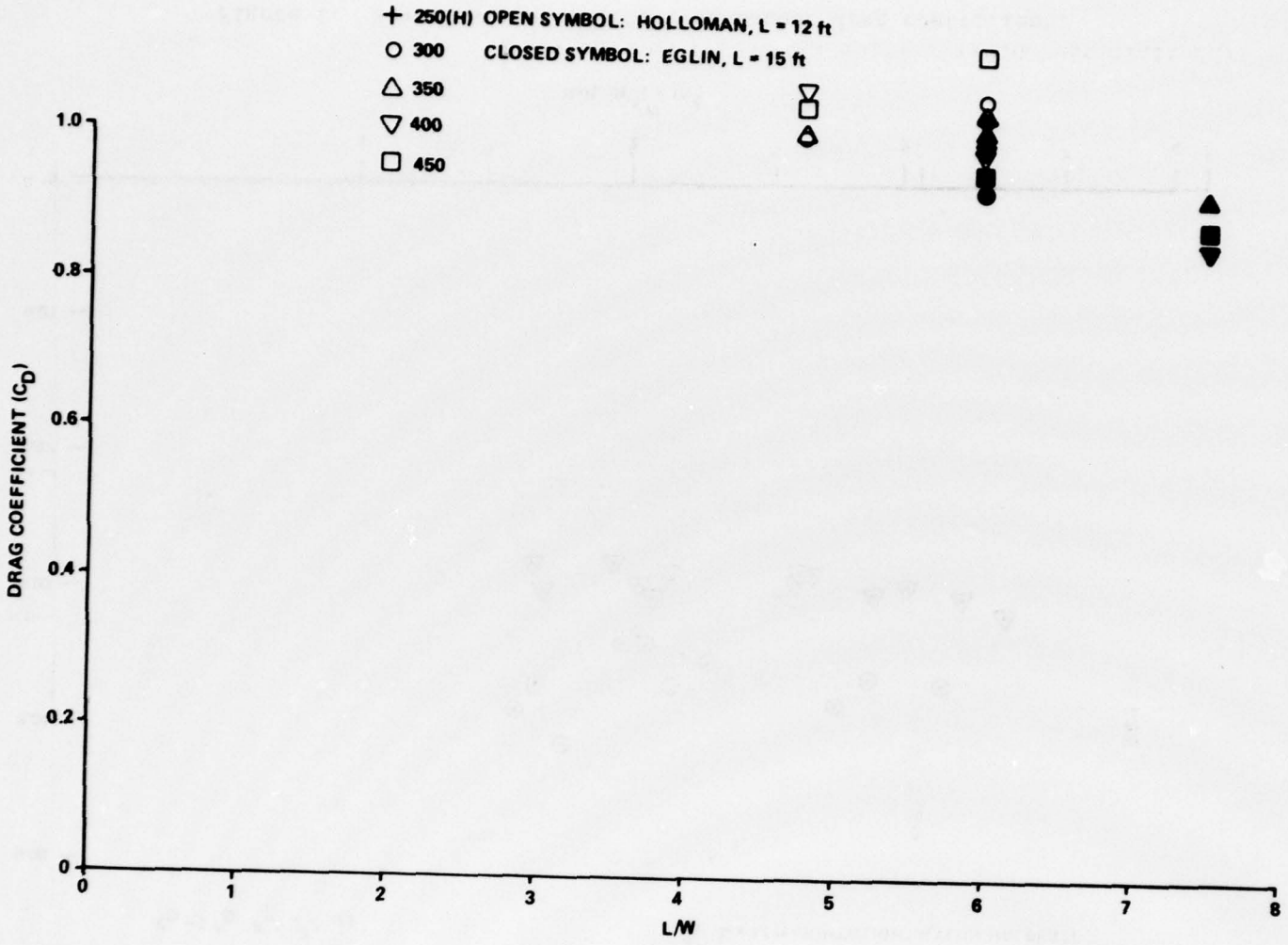


Figure 2(a). Aspect ratio (L/W) on banner drag coefficient (5000-ft altitude).

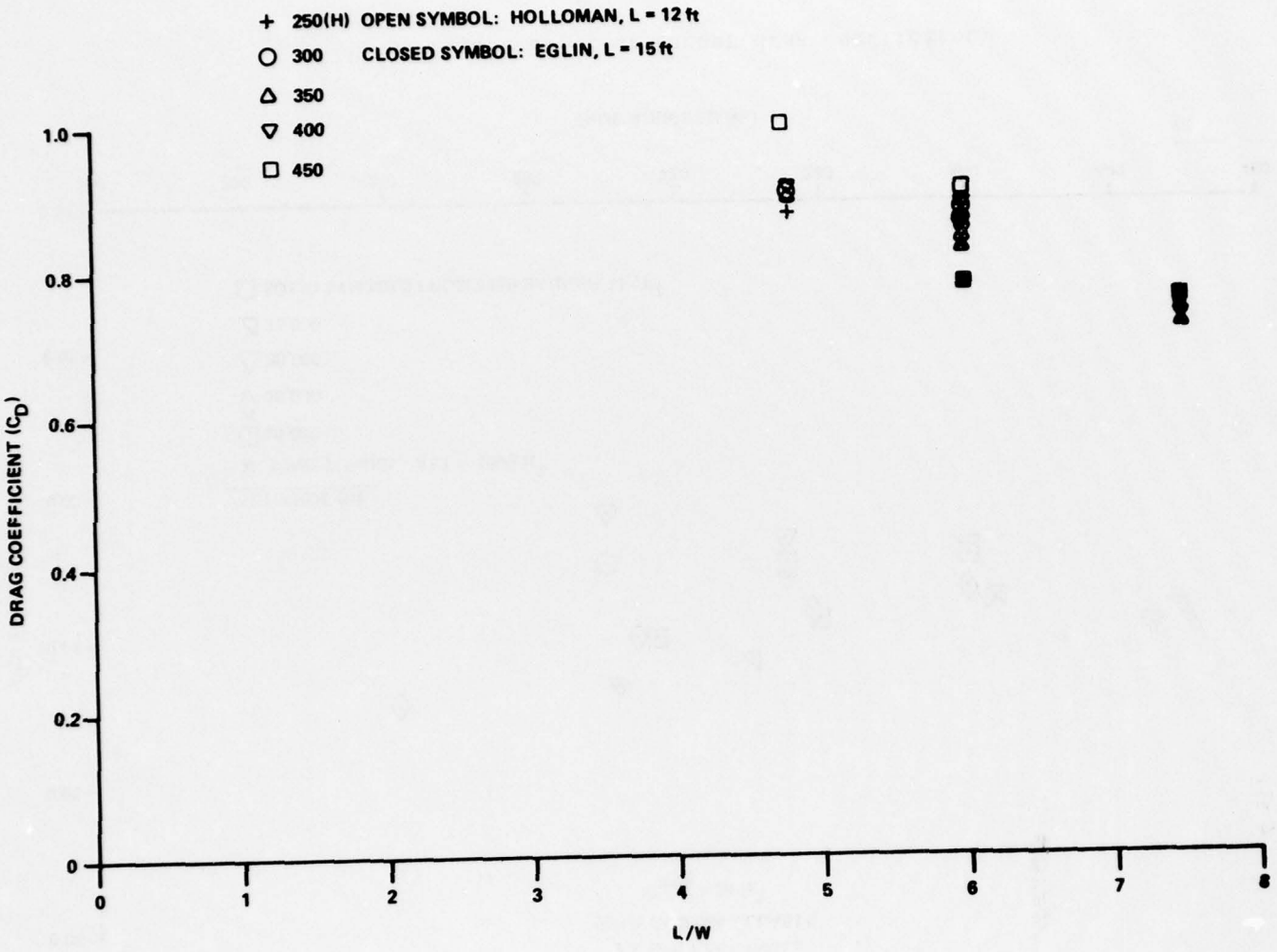


Figure 2(b). Aspect ratio (L/W) on banner drag coefficient (10,000-ft altitude).

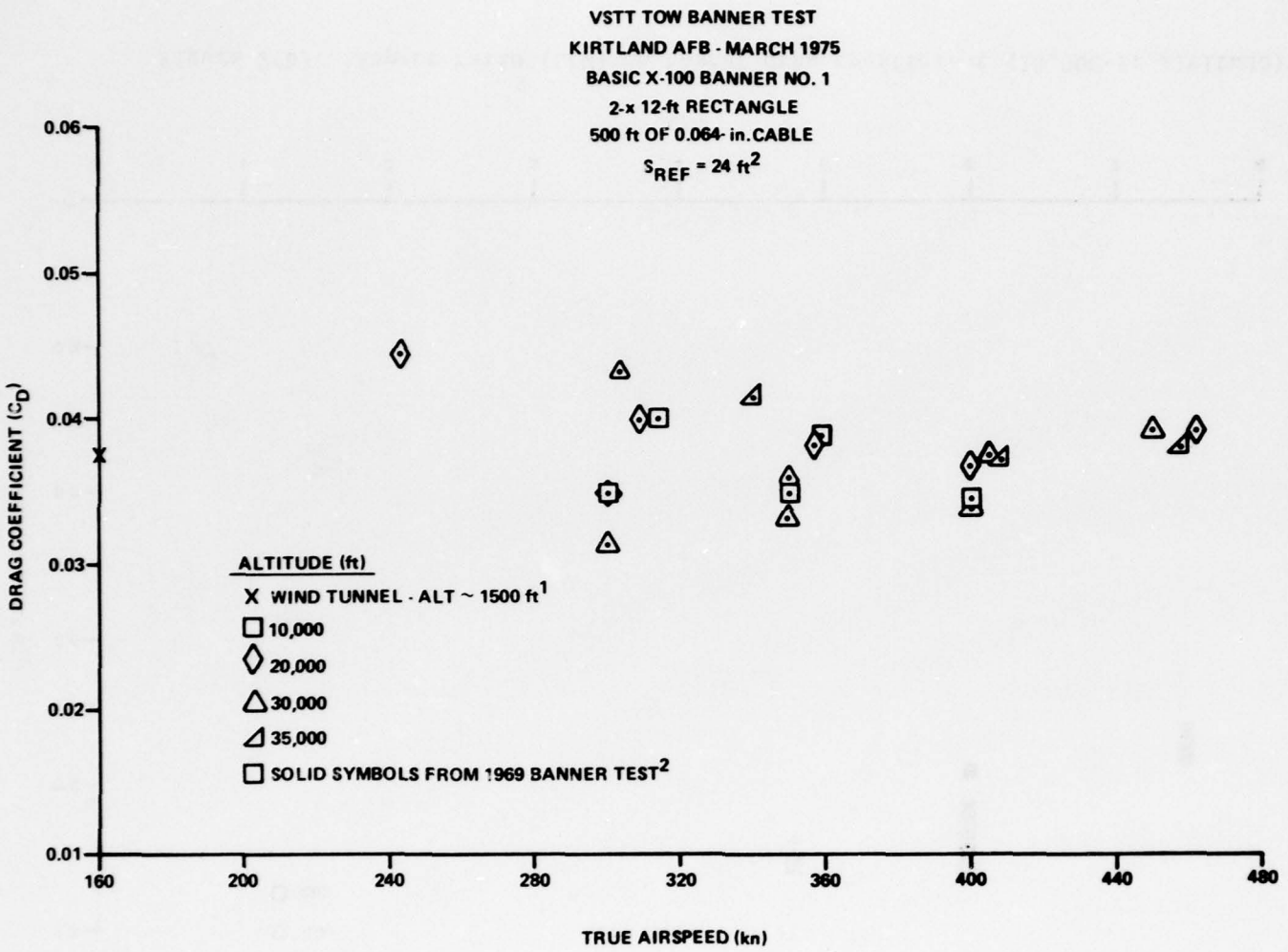
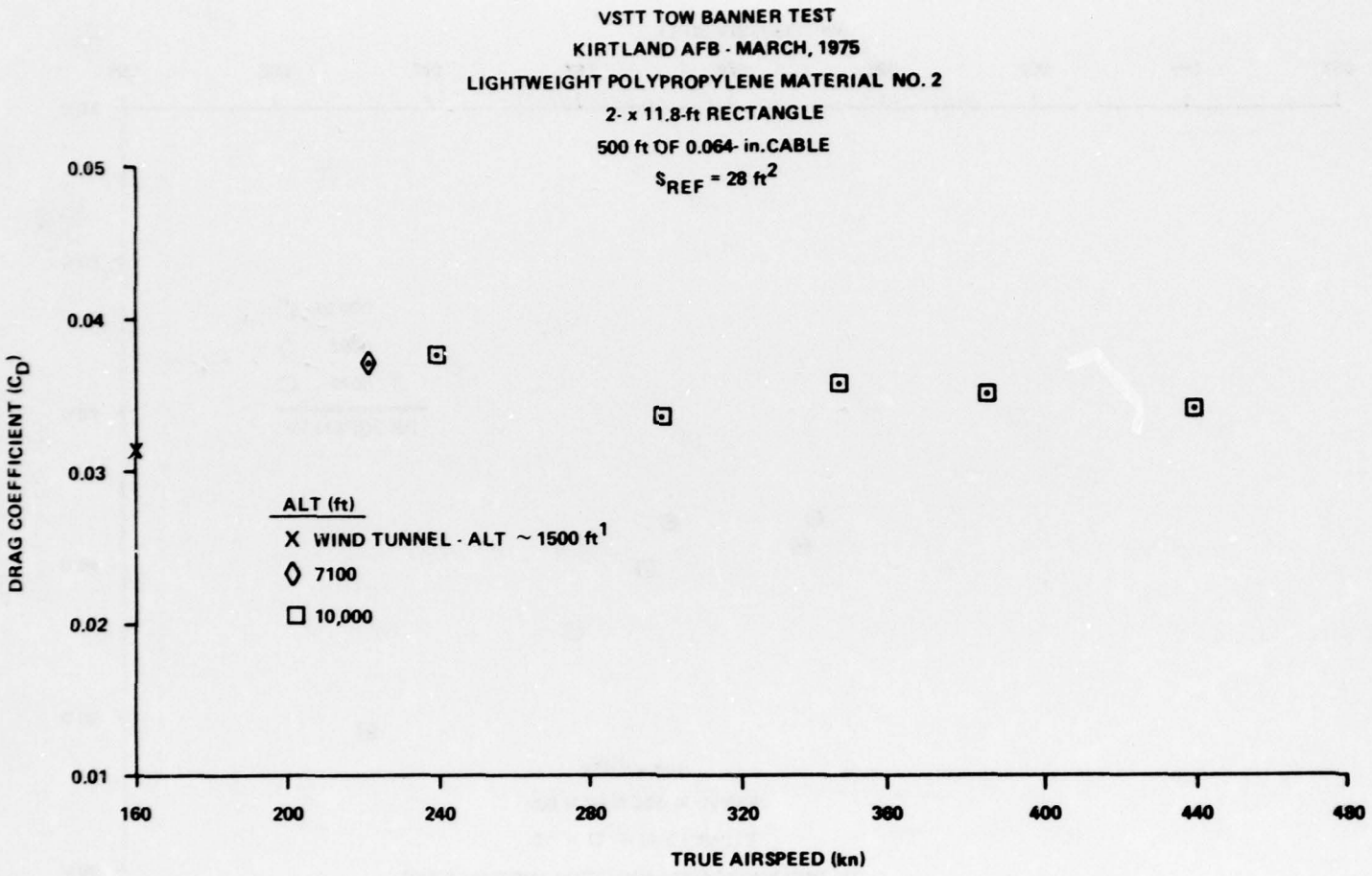


Figure 3. Test banner drag coefficient.



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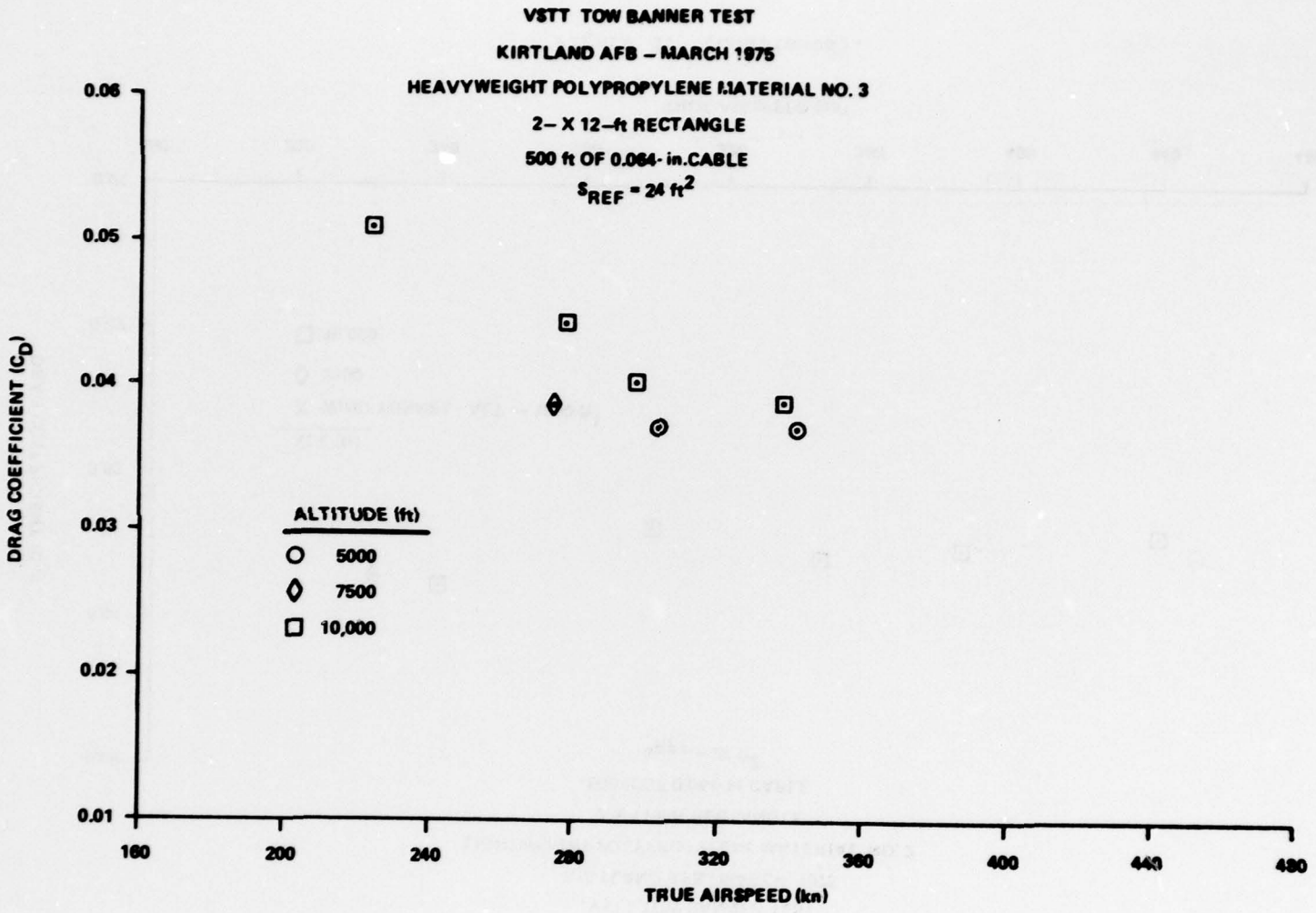

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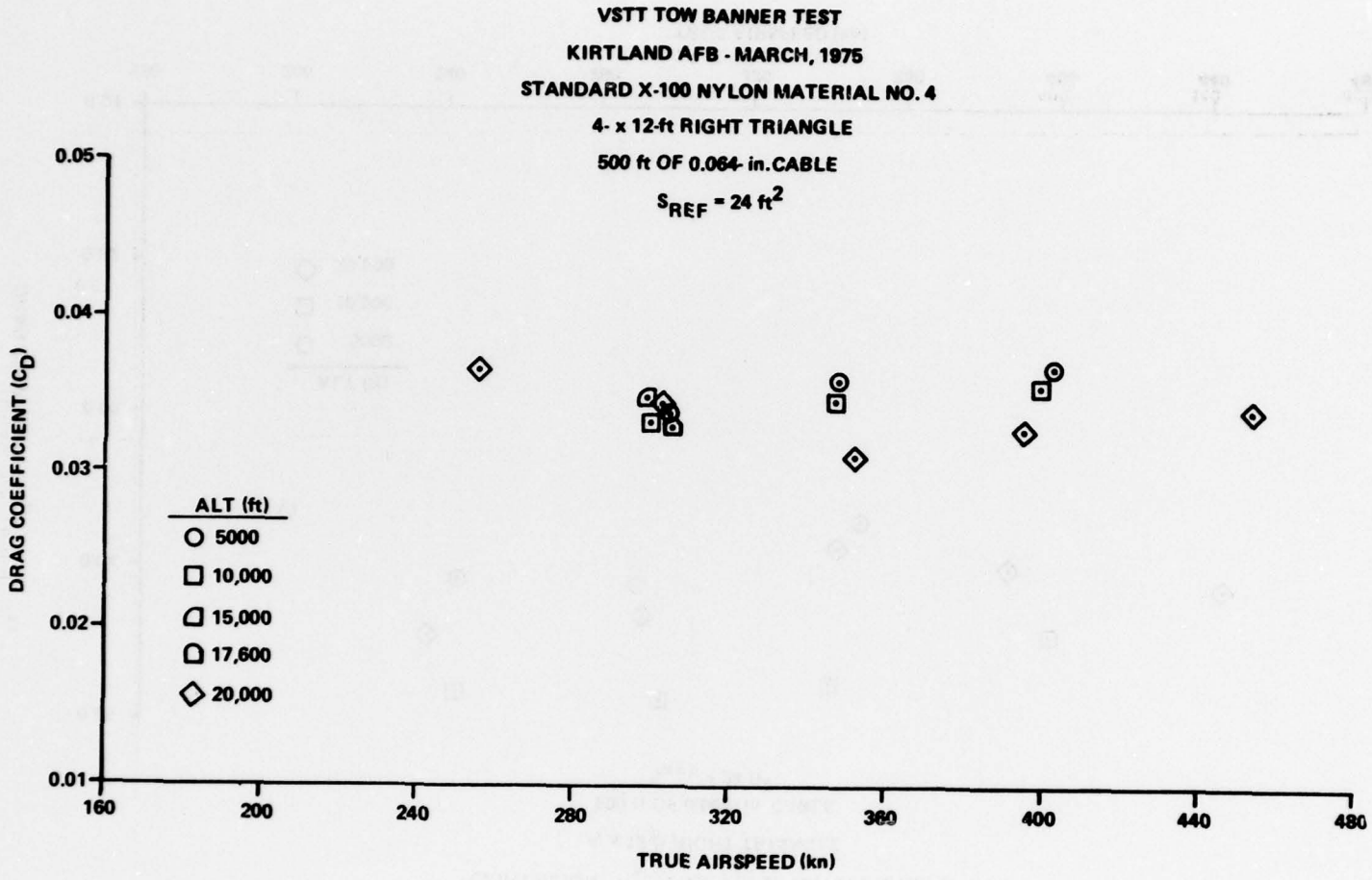

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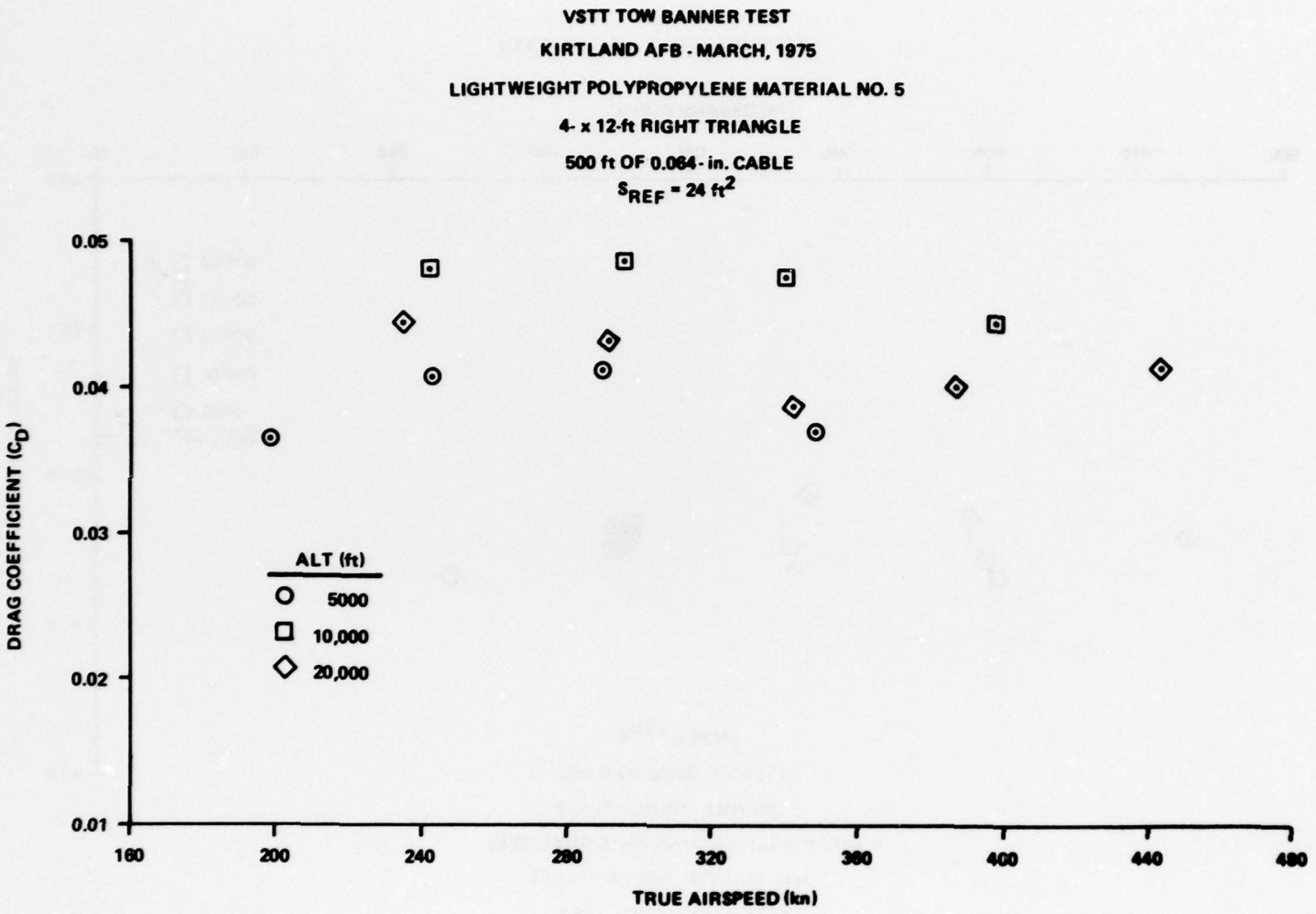

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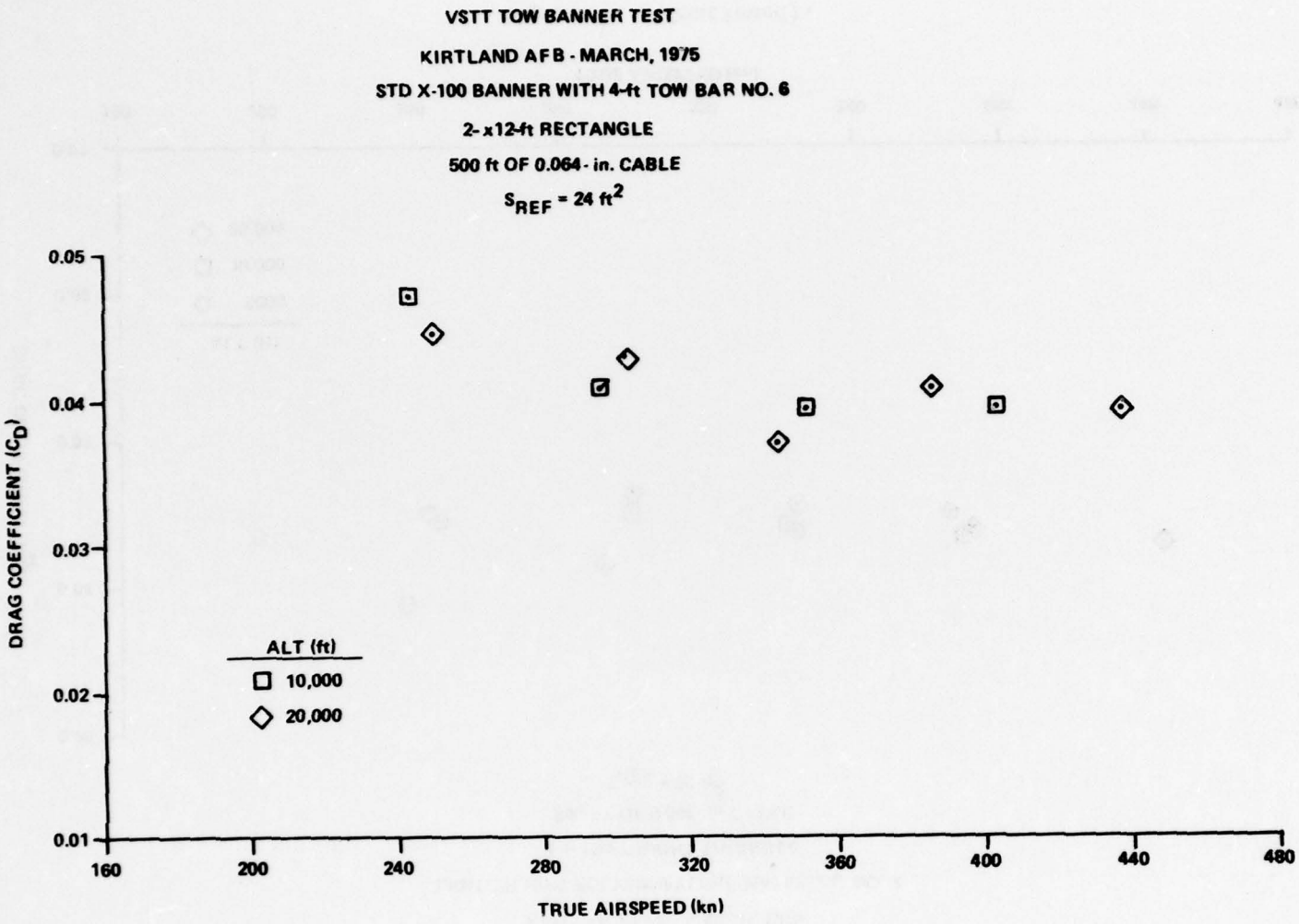

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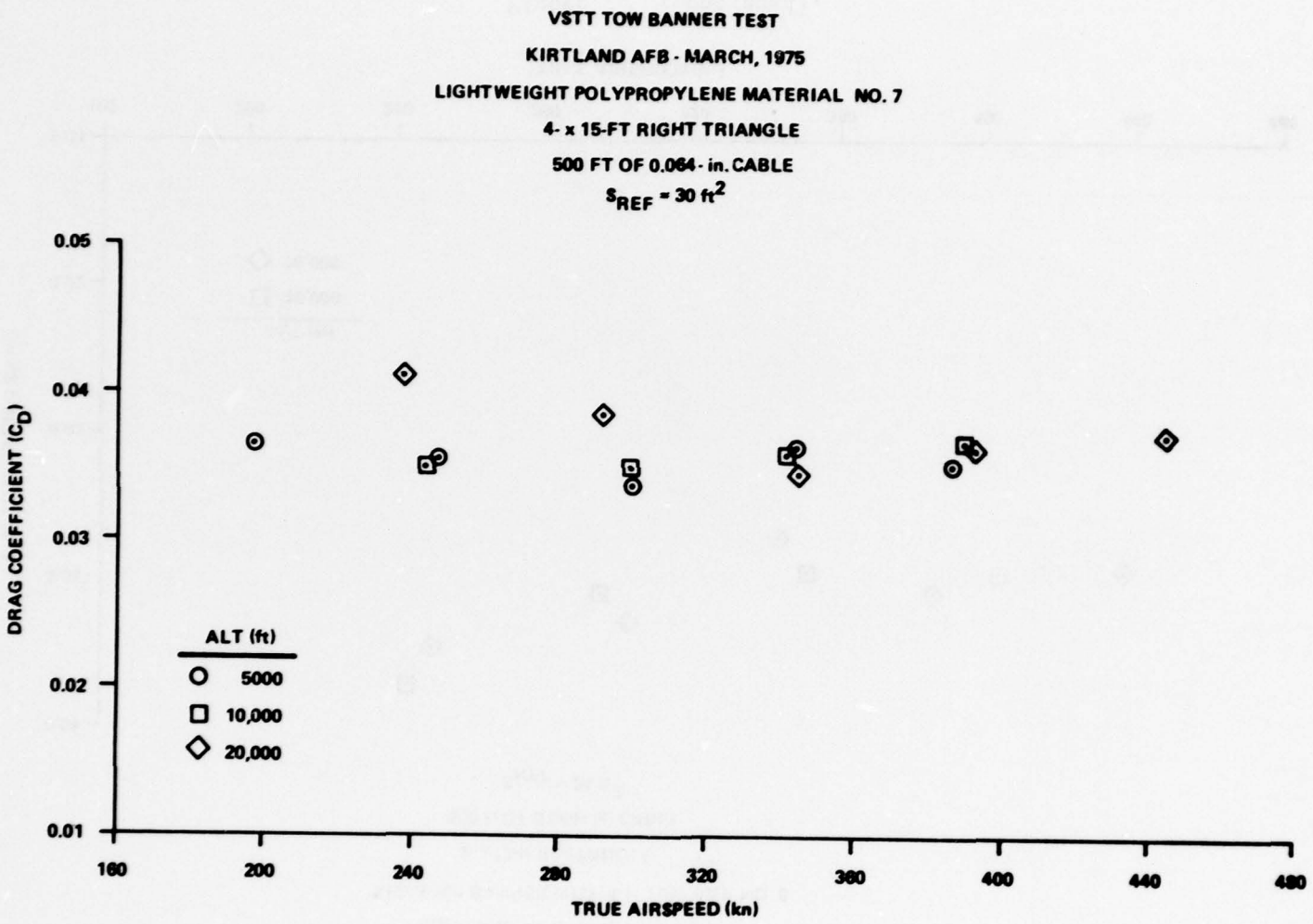

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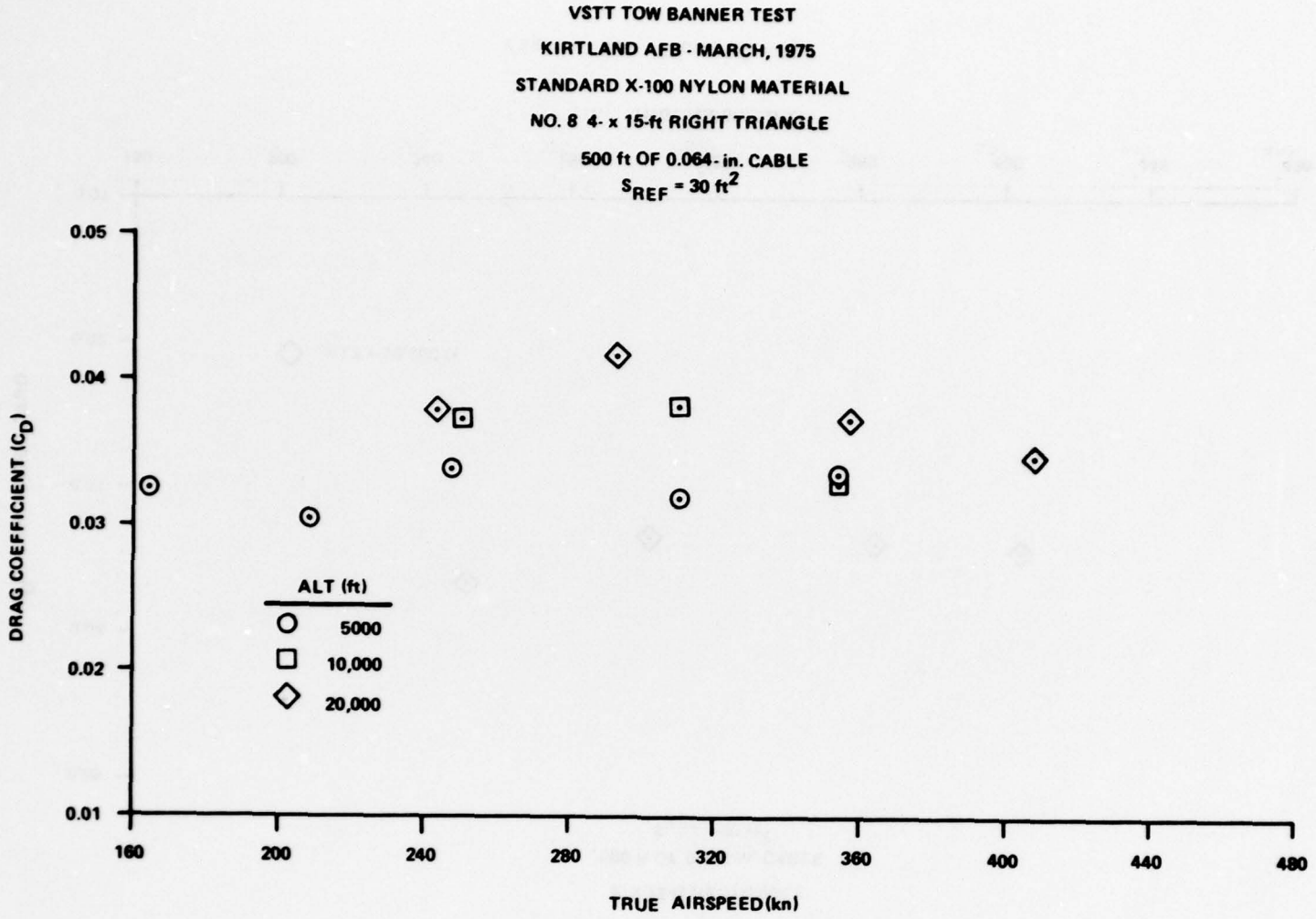

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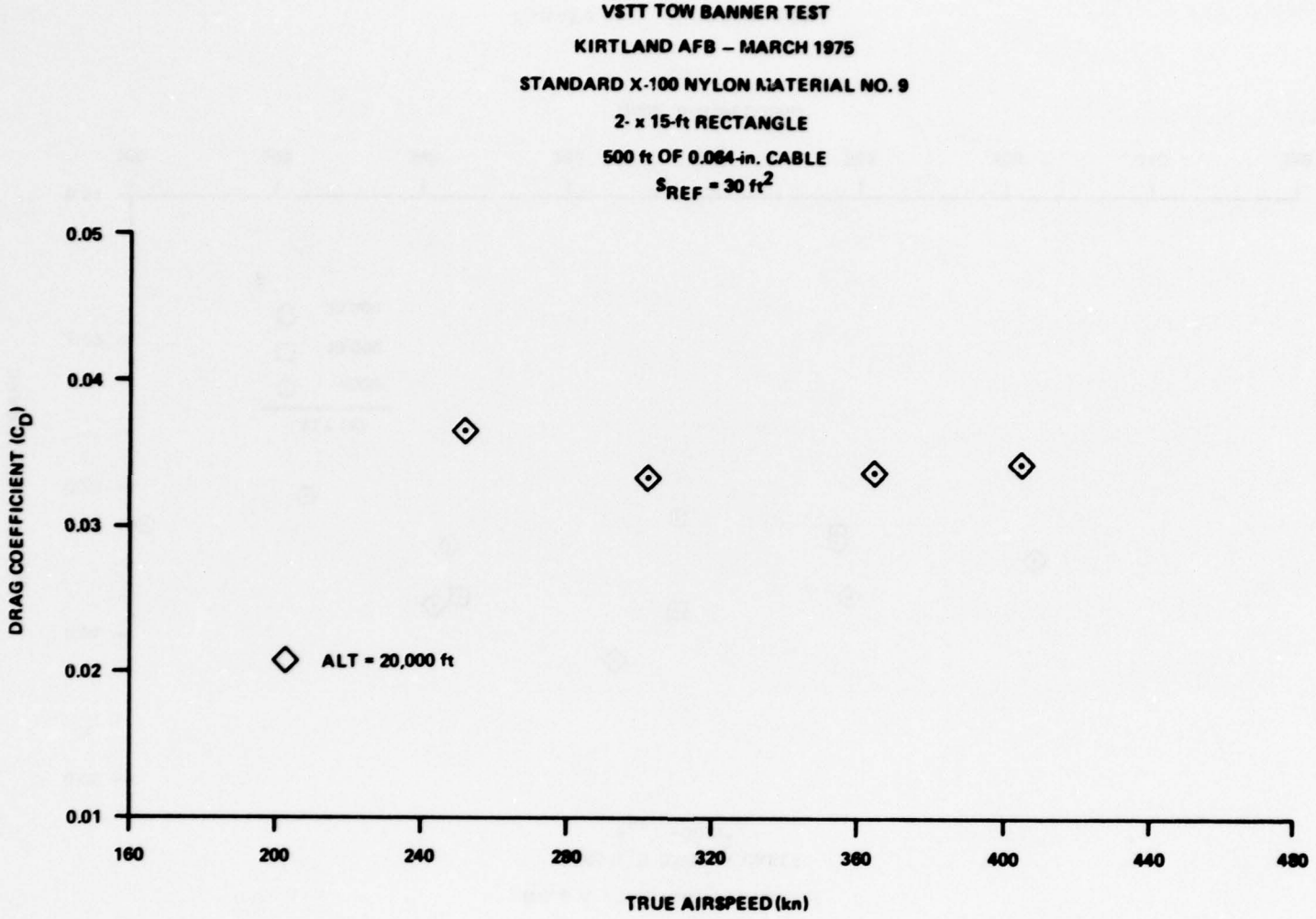

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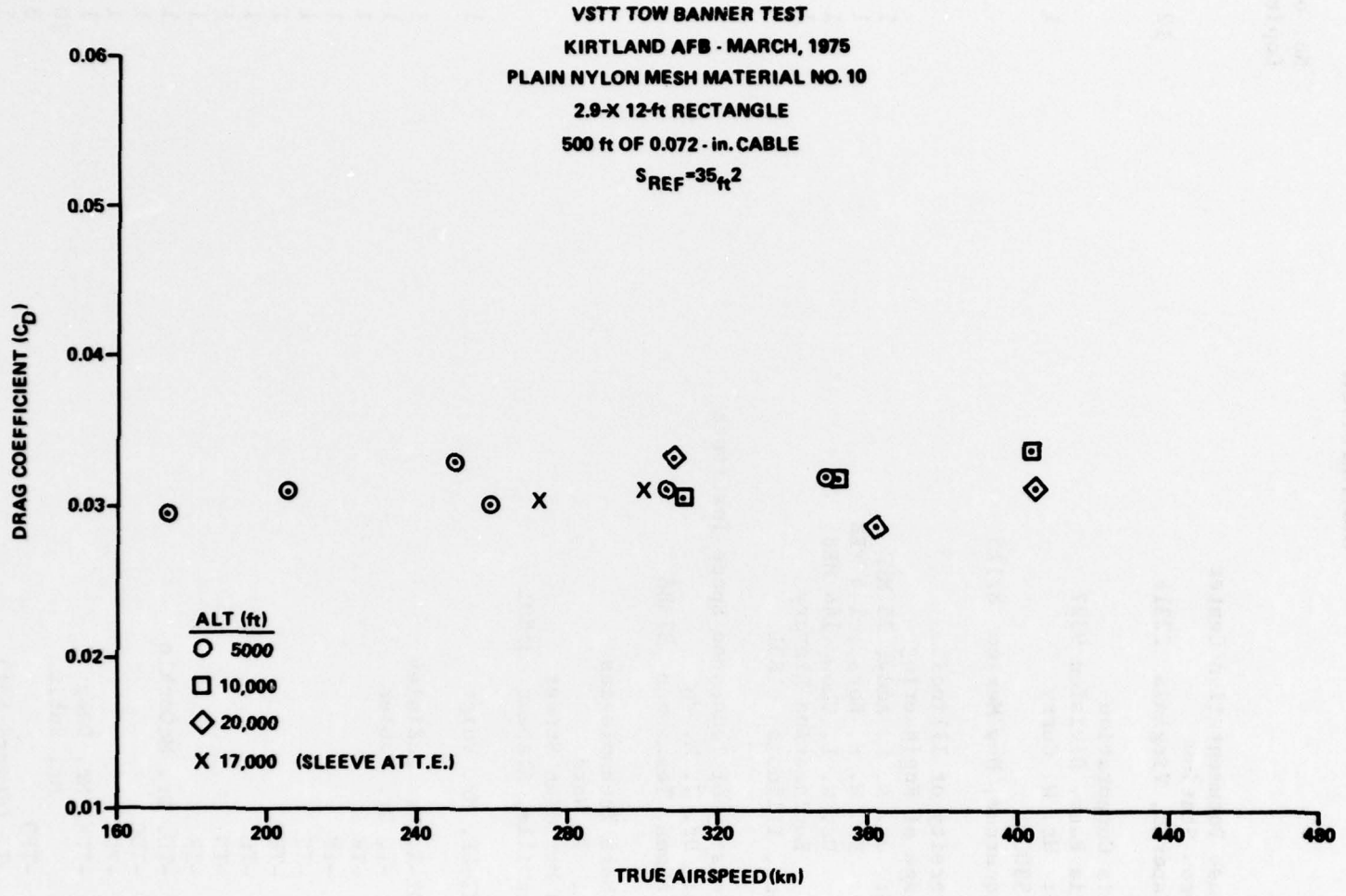

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